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INVESTIGATING THE PERFORMANCE OF CORRODED UNITS OF HYDRAULIC AND PNEUMATIC SYSTEMS

by A. A. Mikhaylov and A. I. Lipin

- USSR -

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- USSR -

[Following is a translation of an article by A. A. Mikhaylov, candidate of technical sciences, and A. I. Lipin, candidate of chemical sciences, in the Russian-language periodical Vestnik mashinostroyeniya (Machine Construction Herald), No. 7, Moscow, July 1962, pages 38-41.]

During the process of long-term operation of various machines and machinery equipped with hydraulic and pneumatic control systems, corrosive action appears on the surfaces of the working parts of such items as cylinders, taps, switches. Particularly strong corrosive action is noticed on parts in systems which operate on alcohol-glycerine mixtures. Less subject to corrosion are parts in pneumatic systems and insignificant corrosion is noticed in parts of units working in hydraulic systems using AMG-10 oil.

The presence of corrosive action on the surfaces of the parts results in a frequent unfounded rejection of a large number of costly units. At the same time, practice has shown the possibility of using such units for a considerable period of time without lowering their technical characteristics.

Following is a description of the results of work conducted for the purpose of establishing the degree of corrosive actions at which normal operation of the units is assurred, and the development of methods for restoring parts with corrosive action.

Testing the technical condition of the units was conducted by means of determining their parameters check-delivery testing programs and inspection of the parts after disassembly of the units. In sum total, tests were made on more than 300 units of hydraulic and pneumatic systems which were in operation for 3-5 years. It was determined as a result of the checks, that the internal surfaces of steel power cylinders are subjected to the greatest corrosive action (Figure 1). In conjunction with this, all subsequent operations were conducted with power cylinders of various types and sizes.

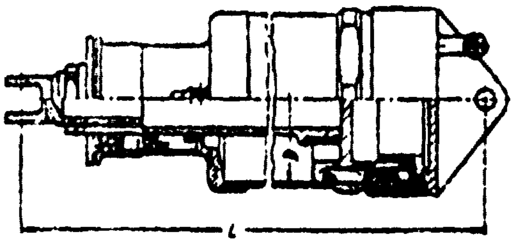

Figure 1.

Longitudinal scratches, low points, and dents were detected on the inner surfaces of such cylinders. The percentage of units, however, which had such defects did not exceed 10-15% of the total

number brought in for repair. By their geometric dimensions, the majority of the cylinders which were within tolerance limits and had no defects other than corrosion. The evaluation of the degree of corrosive action was conducted by measuring the depth of the corrosive pittings and a counting of their number in a unit of area. A clock type indicator inside caliper was used to determine the depth of corrosion. Instead of a stationary pivot, it had a needle-shaped tip mounted on it. An examination of the inner surface and the counting of the number of pittings in a unit of area is done by means of special instruments. In some cases for this, simple devices are used which are in the form of tubes, 7-10 mm in diameter with mirrors fastened at an angle of 45° to the end of the tube. It was established during the inspection process that cylinders operating on alcohol-glycerin mixtures were subjected to corrosive pitting with the number pits being from 1 to 25 per square centimeter. In the majority of cases the pits had the shape of an elongated oval, 1.5-5 m long and 1 mm wide (Figure 2,a). Occasionally 2-3 such pits would be combined and formed into a corrosive action on the surface having a length of up to 40 mm (Figure 2,b). As a rule, the cylinders in pneumatic systems were not subjected to corrosive pits, but to corrosive spots with clear signs of rusting (Figure 2,c).

It was determined from measuring a large quantity of corrosive pits that the characteristic corrosive depths were in the range of 0.2-0.4 mm; maximum corrosive depth was 0.8-0.9 mm. It was also

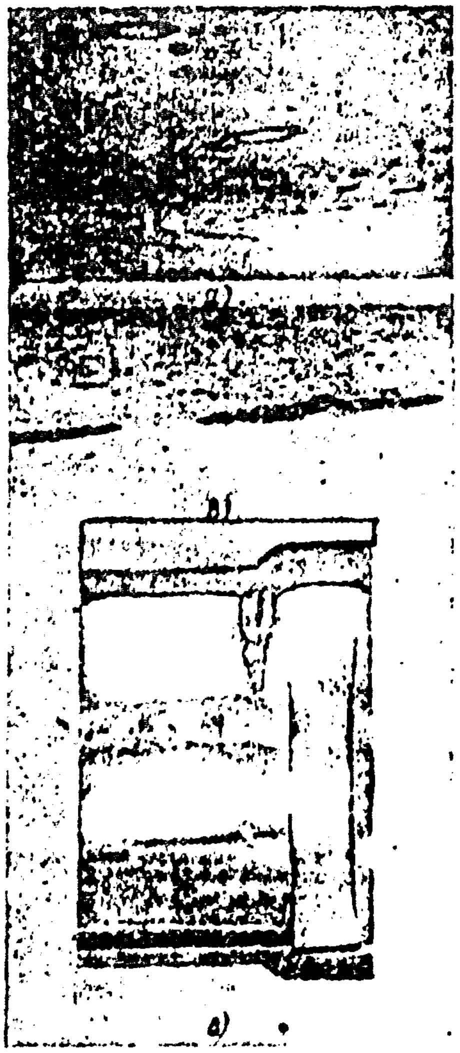

Figure 2. External view of corrosive action on cylinders; x 3.

established that the greater the number of pits in a unit of surface, the less is their depth, and to the contrary: the smaller the number of pits and the greater their size on the surface, the deeper was their depth.

The configuration of the pits inside of the metal has a very specific character: corrosion spreads practically perpendicular to the surface of the metal with a smooth rounding at the bottom (Figure 3). No sub-surface cavitites were discovered.

Figure 3. Microsection of an item with a corrosive pit; x 100.

The removal of corrosive products can best be accomplished by a solution consisting of hydrochloric acid (specific gravity 1.19), 250-280 g/liter, and inhibiter PB-5 in the amount of 8-10 g/liter. The etching time is 8-10 minutes at 18-25°. Further treatment was the neutralization of the acid residue by a solution of potassium sodium bichromate (50-80 g/liter) at 70-80° for a period of 10-15 minutes and a lubrication of the inner surfaces of the cylinders with MS-20 oil at 120-130° for 25-30 minutes. After the removal of the

Corrosion products, the cylinders, on whose inner surfaces considerable wear could be detected, were restored by chroming (layer thickness up to 0.2 mm).

In order to insure a high corrosive resistance on the part of the restored cylinders in later activity, chroming should be carried out under conditions which assure the least development of porous deposits; the cathode current density is 30-35 amp/dm^2 and a temperature of 65-67°.

The depositing of chrome into the corrosion pits may be assurred by maintaining the maximum interelectrode distance (15-30 mm for cylinders open at both ends) and by cone anodes when chroming cylinders closed at one end (anode conus of 1:20-1:35).

For the lengthy stand testings, cylinders of various types (two cylinders each) were selected which had the most frequently encountered corrosive action on them. The tests were conducted according to special programs which were primarily based on cylinder test programs of resource processing compiled by the manufacturing plant.

Ten thousand cycles (double piston strokes) were taken as the base for the testing, this is approximately 3-4 times greater than the factory tests. This was done because the operating resources of the majority of the cylinders are double the guaranteed, as well as with the aim of establishing the actual cylinder working duration prior to loss of hermetic sealing, i.e., to determine the wear resistance reserve factor of the packing ring.

Table 1

Cylinder size (diameter x length) in mm	Technological process of cylinder restoration	Cleanliness of the cylinder surfaces
	Hydraulic system non-chromed cylinders	
45 x 410	Polished	9th
45 x 410	Removal of corrosion products	9th
57.5 x 642		9th
57.5 x 642		9th
60 x 495		9th
60 x 495	Oiling	9th
38 x 152	Honing	12th
38 x 336	Removal of corrosion products	11th
62 x 438	Oiling	11th
62 x 438		12th
80 x 390		11th
	Pneumatic system non-chromed cylinders	
62 x 600	Honing	10th
95 x 335	Removal of corrosion products Oxydising	10th
	Hydraulic system chromed cylinders	
45 x 410	Polishing	10th
45 x 410	Removal of corrosion products	10th
57.5 x 642	Chroming	10th
57.5 x 642	Polishing	7-8th

60 x 495	Polishing	10th
60 x 495		10th
76 x 397		9th
70 x 680	Polishing	11th
70 x 680	Removal of corrosion products Chroming Polishing Chroming	12th

Table 1 (continued)

Degree of the corrosive action		Number of cycles prior to loss of hermetic sealing, ata
Number of corrosive pits per 1 cm^2	Depth of the corrosion, in mm	
2-3	0.1-0.2	10,000
5-6	0.3-0.5	10,000
3-4	0.05-0.15	2,500
6-9	0.15-0.65	2,500
2-5	0.2-0.3	2,500
7-10	0.5-0.7	2,500
8-10	0.6-0.7	10,000*
3-5	0.7-0.8	10,000*
15-20	0.2-0.3	10,000*
15-20	0.2-0.3	10,000*
3-5	0.7-0.8	10,000*
15-20	0.05-0.4	10,000*
6-8	0.2-0.4	10,000*
2-3	0.2-0.3	10,000*
2-3	0.2-0.5	10,000*
10-14	0.4-0.8	10,000*
3-5	0.2-0.4	2,500**

8-15	0.5-0.6	10,000*
5-10	0.4-0.5	10,000*
20-25	0.05-0.02	5,000
10-15	0.3-0.4	10,000*
15-20	0.2-0.3	10,000*

Notes: * Cylinders removed from testing after the entire program had been completed.

** Treatment was conducted with rough grinding conditions without subsequent polishing.

*** All cylinders were subjected to strength tests under a pressure of 400 ata.

Table 1 (continued)

Surface conditions of

Cylinders***

Wear to 0.01 mm with well defined scratches

As above

As above

As above

As above

As above

No wear or visible defects (scratches, dents, etc.)

As above

As above

As above

As above

No wear. Insignificant scratches.

As above

No wear or visible defects (scratches, dents, etc.)

As above

As above

Noticeable traces after mechanical processing, longitudinal scratches.

No wear or visible defects (scratches, dents, etc.)

As above

Clearly visible scratches

No wear or visible defects (scratches, dents, etc.)

As above

Table 1 (continued)

Surface conditions of

Rubber rings

Wear and local tearing
As above
As above
As above
As above
As above
No wear. Lightening in some areas.
As above
As above
As above
As above
Lightening over the entire surface
As above
No wear, insignificant lightening
As above
As above
Heavy wear and eruptions of rubber over the entire ring surface.

No wear. Slight lightening.

As above

Wear over the entire surface with tears in 2-3 points.

No wear

As above

Two cylinders were tested simultaneously; a counter-resistance was developed on the cylinder rods equal to 0.7–0.8 of the maximum force. The results of the long tests conducted on stands for cylinder wear for the purpose of establishing optimum amounts of corrosion and checking the restoration methods are given in Table 1.

It is evident from the material presented that the non-chromed cylinders with a ninth grade surface cleanliness lose hermetic sealing after 2,500 cycles.

The chromed cylinders sustained the full testing program. There was virtually no loss in the geometric dimensions of the cylinders after the testing program when compared to the same measurements prior to testing. Also, no visible defects, such as scratches, etc., were noticed on the working surfaces of the cylinders. It is necessary to mention that the wear resistance of the packing rings, working against chrome, is somewhat higher than that for rings working against steel, and which is explained by the different friction factors.

To determine the effect of surface cleanliness on the wear resistance of the packing rings, the 57.5 and 76 mm diameter cylinders were treated with a varying roughness. Cylinder testing was conducted simultaneously. The cylinders which had a tenth grade surface cleanliness withstood the full testing program — 10,000 cycles. After testing, the rubber packing rings were in very good shape. Cylinders with a ninth grade surface cleanliness stood up for 5,000 cycles, and those with a 7th–8th grade surface cleanliness only 2,500 cycles with

a strong wear on the rubber packing rings. With this, there were 2-3 times more corrosive pits on like cylinders having a 10th grade surface cleanliness. Thusly, the wear resistance of the packing rings depends primarily on the roughness of the cylinder surface and not on the corrosive pits. Therefore, the processing of cylinder surfaces should be done with a cleanliness of not less than the 10th grade which may be easily reached by chroming.

The obtained results of the experimental tests, with a consideration for the increased number of cycles in the testing program, permits the following recommendations to be made concerning the repeated resource of hydraulic and pneumatic system cylinders (chromed and non-chromed) having the following corrosive actions:

1) the corrosion depth for cylinders operating in systems with AMG-10 oil is not more than 0.9 mm, and not more than 0.6 mm with alcohol-glycerine mixture and air. With an increased (repaired) cylinder diameter, the corrosion depth is decreased by a value equal to the decreased thickness of its wall from the nominal size;

2) the length of the corrosive actions, in the form of lines, must not exceed 10 mm (if the distance between them is not less than 30 mm);

3) the number of corrosive pits with a diameter or length of not over 1 mm must not be more than 7 to 1 cm^2 (this can include one corrosion defect in the form of a line having a length of up to 10 mm);

4) the number of corrosive actions with a diameter of 2-3 mm must not exceed 3 per 1 cm^2.

The methods for the restoration of pneumatic and hydraulic system cylinders, the degree of whose corrosive action on the inner surfaces does not exceed the above-indicated limits, are shown in Table 2.

Table 2

Cylinder condition	Diagram of the technological process of restoration
The geometrical dimensions are within tolerance limits, the inner surfaces do not have scratches, scores, or low points	1. Cleaning the inner surfaces of the cylinders by honing or polishing with a felt cloth using GOI paste until a surface cleanliness of not less than the 10th grade is achieved. 2. Removal of corrosion products. 3. Anti-corrosion treatment. 4. Oiling.
The geometrical dimensions deviate from the tolerance limits, scratches and low points to 0.05 mm.	1. Grinding and honing or only honing of the cylinder to a diameter exceeding the nominal size by not more than 0.1 mm. Cleanliness of the processed surface must not be less

than the 10th class.

2. Removal of corrosion products.

3. Anti-corrosion treatment.

4. Chroming of the cylinder (or piston) until a clearance is reached which is within the limits set in the current technical documents (with an overmeasure for treatment).

5. Mechanical processing of the chromed items until a surface cleanliness of not less than the 10th class is achieved.

The geometrical dimensions deviate from the tolerance limits, scratches and low points from 0.06 to 0.2 mm.	1. Grinding the cylinder until the removal of the defects and the required geometric size received, but not greater than the limits set according to the respective documents. 2. Honing. 3. Removal of corrosion products. 4. Chroming. 5. Grinding after chroming. 6. Cylinder honing until series size and 10th class cleanliness is reached.

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